Performance-based Regulation Compensation

Improve PJM Market Efficiency

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FERC Order 755

Frequency Regulation Compensation in the Organized Wholesale Power Markets

- On October 20, 2011, FERC issues Order 755.

- The Order required RTOs and ISOs to compensate frequency regulation resources based on the actual service provided, including:

  - a capacity payment that includes the marginal unit's opportunity costs and

  - a payment for performance that reflects the quantity of frequency regulation service provided by a resource when the resource is accurately following the dispatch signal.

- The order requires that the performance compensation must be based on:
  - delay time,
  - dispatch accuracy and
  - Mileage

  in response to the system operator's dispatch signal.

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Background and Benefits of FERC Order 755

- Prior to Order 755, regulation compensation practices of RTOs /ISOs only considered capacity payment, performance for frequency control was not considered in regulation market clearing and settlement ;

- Drawbacks of market structure:
  - no sufficient incentive for regulation resources to quickly and accurately respond to frequency control signal;
  - operational inefficiency caused by increased regulation requirement to make sure system can meet reliability criteria set by NERC.

- A PNNL study concluded that fast-ramping energy storage resources could be as much as 17 times more effective than conventional ramp-limited regulation resources. The Order intents to provide efficient incentive for investment in well-performing regulation resources.

- Due to increasing penetration of intermittent resources and demand resources, more regulation capabilities are needed to effectively manage the rapid variation of supply and demand in power systems. PBR development also aligns with increased need for regulation.

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PERFORMANCE BASED REGULATION (PBR) INTEGRATION INTO PJM

- PBR model has been operating in PJM production environment since October 1, 2012.

- PJM RT Business Processes
  - ❑ AS market (ASO): **PBR Integrated**
    - ▪ Kicks off one hour ahead of target time;
    - ▪ clearing Reg, synchronized reserve (SR) and primary reserve (PR);
  - ❑ Intermediate-Time Security-Constrained Economic Dispatch (IT SCED);
    - ▪ kicks off 15 minutes ahead of target time;
    - ▪ performs an incremental commitment recommendation of fast-start resources for energy, SR and PR.
  - ❑ Real-Time Security-Constrained Economic Dispatch (RT SCED);
    - ▪ kicks off 15 minutes ahead of target time;
    - ▪ dispatch energy and assign resources for the remaining SR and PR requirements;
    - ▪ sends out dispatch signals to market participants.
  - ❑ Locational Price Calculator (LPC) **PBR Integrated**
    - ▪ provides energy LMP and AS Market Clearing Prices (MCP) for Reg, SR and PR.

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- **Reg Signal Types**
  - RegA: sent to traditional regulating resources, such as steam and combined cycle units.
  - RegD: sent to dynamic or fast response regulating resources, such as batteries and flywheels.

- **Two-part Regulation Offer**
  - a capability offer (RegA and/or RegD)and;
  - a performance offer (RegA and/or RegD).

For a resource qualified for both RegA and RegD offers, i.e., dual-following resources, two offers may have different MW values and different offer prices.

For a dual-following resource, offer shall be cleared exclusively with the least system operation cost.

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- **Performance Score(PScore)**

  - Calculated by Performance Score Calculation Engine(PSCE);

  - Based on timeliness, accuracy and precision of response to regulation signal historically;

  - Value between 0 and 1

- **Mileage Ratio**

  - Calculated by PSCE, represents mileage per MW regulation offer deployment for frequency control.

  - is used to normalize the performance between RegA and RegD signal types;

  - Typical ratios for RegA are 3-6 ΔMW/MW of capability; RegD, 10-16 Δ MW/MW.

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- **Benefit Factor (Bfactor)**

  - Constructed by PJM, BFactor curve has two or more segments, it may change by season;

  - Only apply to RegD offers. BFactor is decreasing with more available adjusted RegD offer MW.

  - The impact of BFactor is an increase in the likelihood of fast-following resources getting cleared, up to the point of diminishing returns, i.e., point 2. The low value after point 2 is to prevent the market from clearing more RegD offers than RegD resources can provide in practical systems.

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PBR Model in PJM
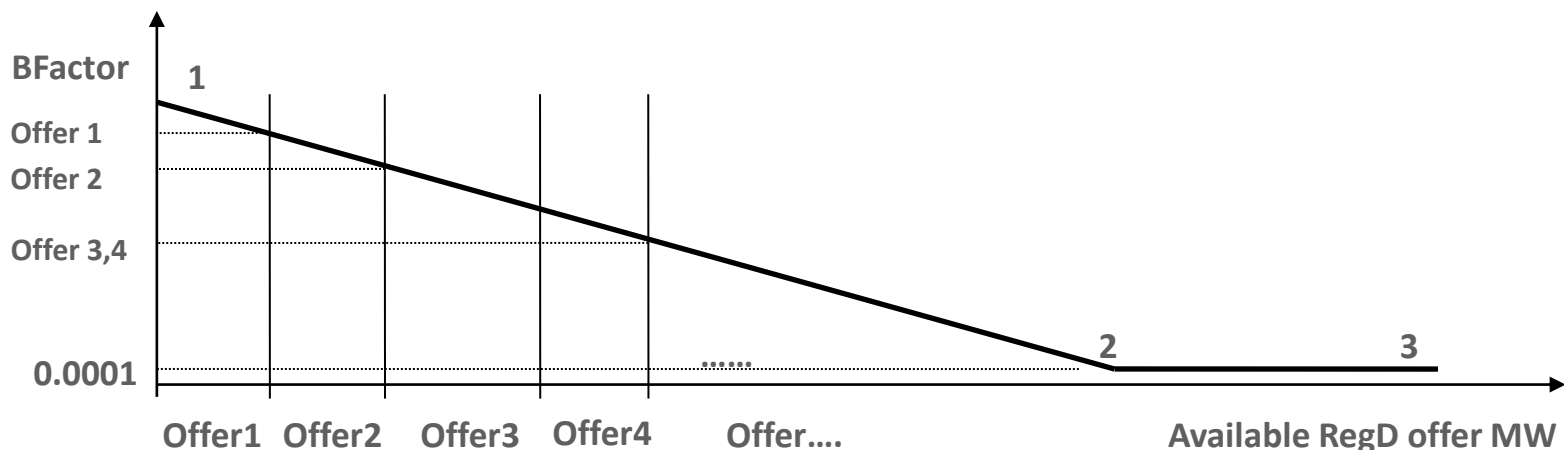
- **Adjustment to Regulation Offer Prices**

  - $Adjusted\ Reg\ Cap\ Offer\ Price = \dfrac{Cap\ offer\ Price}{BFactor \times PScore}$

  - $Adjusted\ Reg\ Perf\ Offer\ price = \dfrac{Perf\ offer\ Price \times Mileage\ Ratio}{BFactor \times PScore}$

  - $Total\ Reg\ Offer\ Price =$

    $Adjusted\ Reg\ Cap\ Offer\ price + Adjusted\ Reg\ Perf\ Offer\ price$

  - Adjustment by the PScore will make poor-performing resources appear more costly;

  - Mileage ratio makes the adjusted performance offer price can reflect resource movement in response to frequency control signal;

  - BFactor is used to make faster units appear more economically attractive to the market up to the point they are beneficial.

- **Adjustment to Regulation Offer MW**

  - $Effective\ Reg\ Offer\ MW = BFactor \times PScore \times Bid\_in\ Reg\ OfferMW$

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- **Objective Costs Term for Regulation Clearing**

$$Total\ costs\ of\ Reg\ clearing = $$
$$RegA\ Adjusted\ Offer\ Price \times RegA\ product\ clearing\ MW +$$
$$RegD\ Adjusted\ Offer\ Price \times RegD\ product\ clearing\ MW$$

- **System Level Regulation Requirement Constraint**

$$Total\ Reg\ service\ clearing \geq system\ Reg\ requirement$$

Where

$$Total\ Reg\ service\ clearing$$

$$= \sum (Reg\ product\ clearingMW \times BFactor \times PScore)$$

- **Resource Level Regulation Product Clearing**

$$Reg\ Product\ clearing\ MW \leq Bid\ in\ Reg\ Offer\ MW$$

$$DispatchMW + RegProduct\ clearing\ MW \leq RegMax$$

$$DispatchMW - RegProduct\ clearing\ MW \geq RegMin$$

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- **RMCP For Reg Market Settlement**

$$RMCP = Max(cleared\ reg\ resources, Total\ Reg\ Offer\ Price + Reg\ LOC)$$

Where

$$Reg\ LOC = \frac{LMP - Energy\ Marginal\ Price}{BFactor \times PScore}$$

- **RMCP includes:**
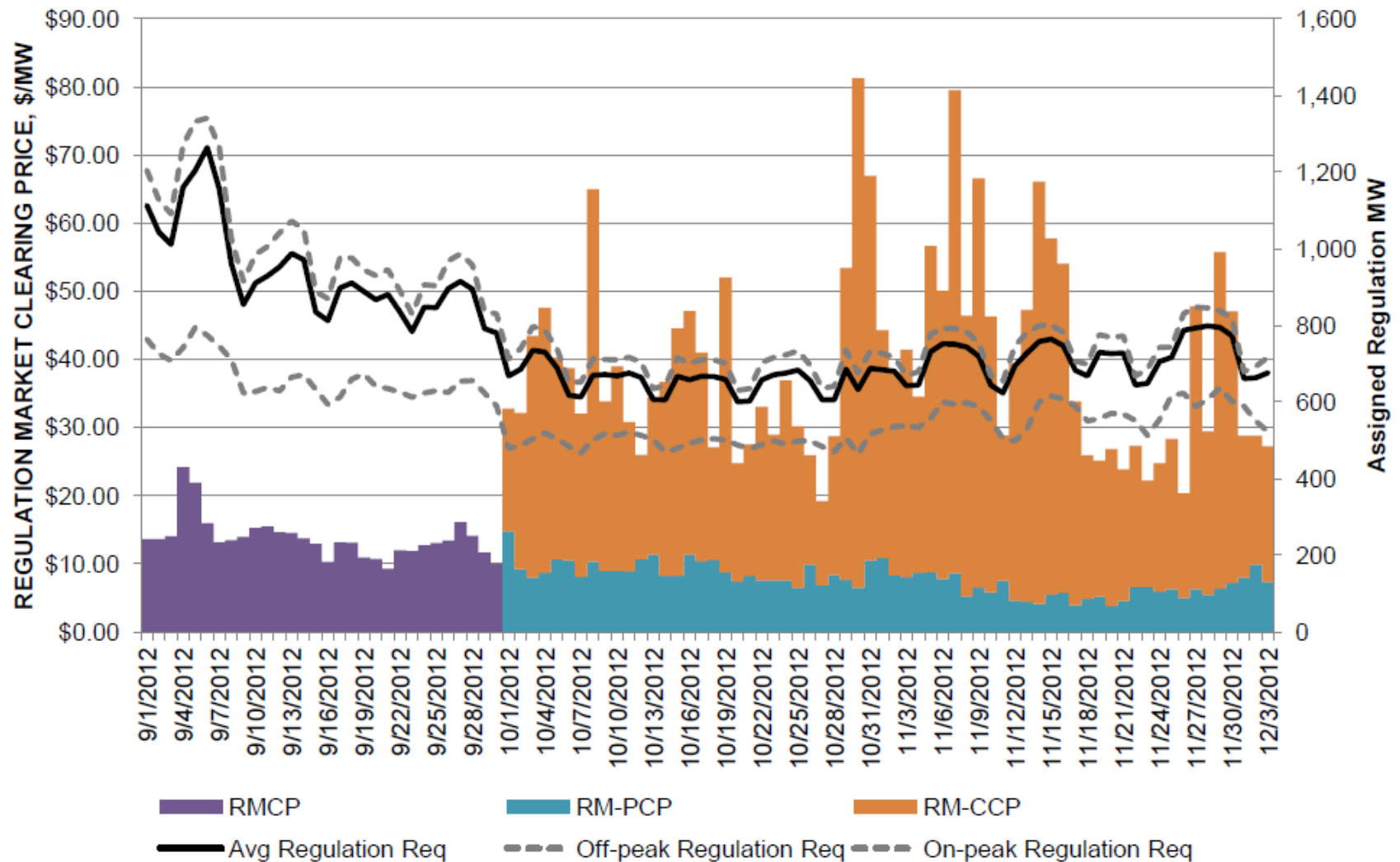
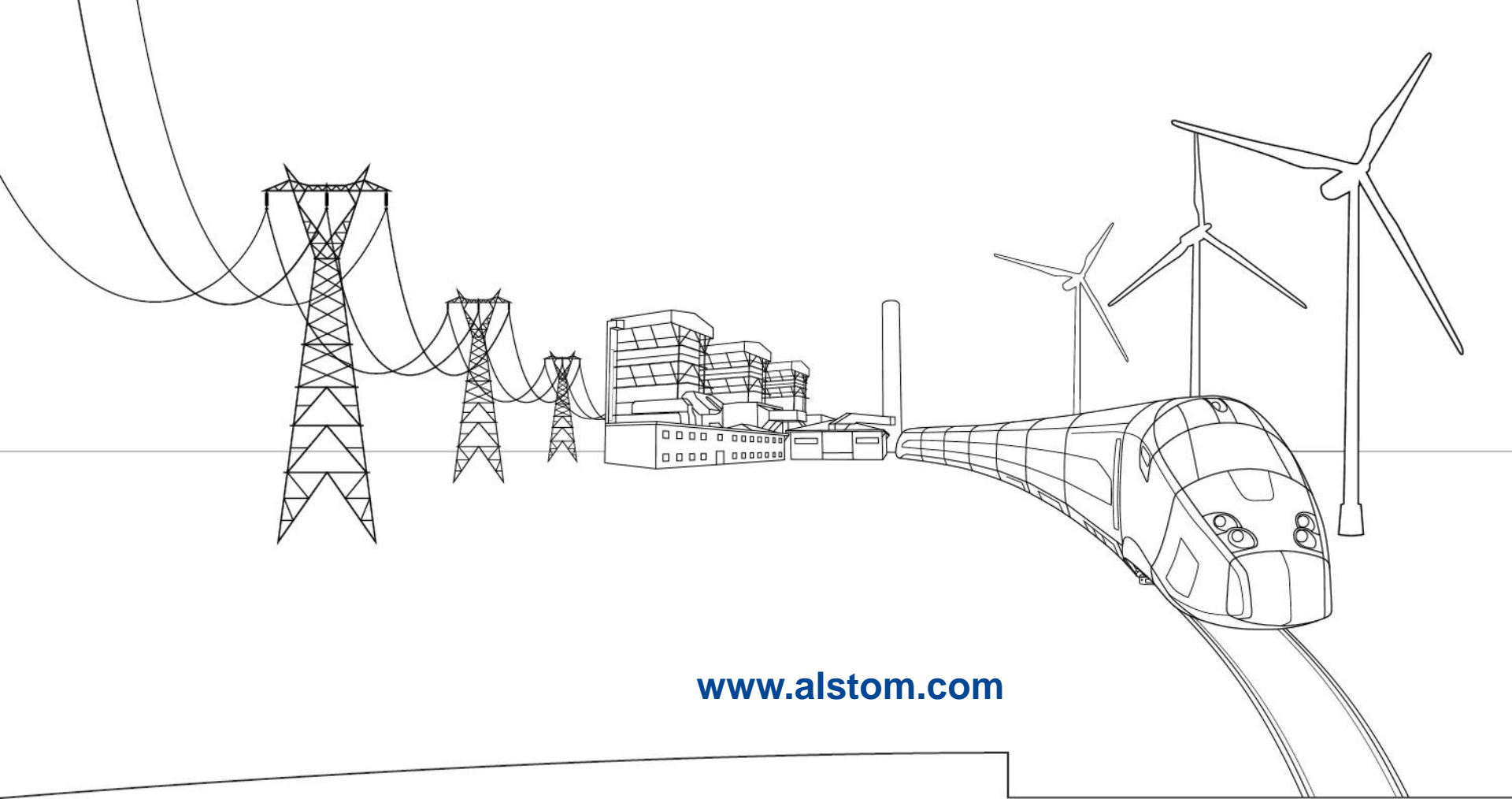 – Capability Clearing Price (CCP) and,
  – Performance Clearing Price (PCP).

$$PCP = Max(cleared\ reg\ resources, Adjusted\ Reg\ Perf\ Offer\ Price)$$
$$CCP = RMCP - PCP$$

CCP and PCP are for information only.

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